(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 285 147 B2

(12) NEW EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the opposition decision:
24.06.1998 Bulletin 1998/26

(45) Mention of the grant of the patent:
31.03.1993 Bulletin 1993/13

(21) Application number: **88105209.6**

(22) Date of filing: **30.03.1988**

(51) Int Cl.[6]: **H01F 6/00**, H01B 12/06

(54) Current-carrying lead

Stromführende Leitung

Conduite transporteuse de courant

(84) Designated Contracting States:
DE FR GB

(30) Priority: **31.03.1987 JP 80401/87**
31.03.1987 JP 80408/87

(43) Date of publication of application:
05.10.1988 Bulletin 1988/40

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- **PATENT ABSTRACTS OF JAPAN vol. 10, no. 373 (C-391)(2430) 12 December 1986 & JP-A-61 168530**

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Description

BACKGROUND OF THE INVENTION

The present invention relates to a current-carrying lead for supplying an electric current to superconducting magnets and like devices.

An electric current is supplied to superconducting magnets and other superconducting devices by means of current-carrying leads provided between the source of current supply and the device. Conventionally, such current-carrying leads are made of copper conductors in rod or pipe form. However, copper has both electrical conducting (non-superconducting) and thermal conducting properties. Because of these properties, the heat generated by the copper conductor when a current is applied and the heat transmitted from the terminal on the hot side are conducted to liquid helium. liquid nitrogen or other cryogenic media (cryogens) in which the superconducting magnet is submerged, thereby causing such cryogens to evaporate.

To minimize the heat conduction to liquid helium, several method have been proposed for use with prior art current-carrying leads and one common approach is depicted in Fig. 1. There, spiral cooling fins 110 are provided on the surface of the lead which is accommodated in a stainless steel sheath 120. Notwithstanding this cooling structure, the helium gas 130 is evaporated by the heat of conduction drawn into the lead 100 from a terminal 140 connected to the superconducting magnet and the heat generated by the electrical current supplied to the magnet through the cooled lead and a terminal 150. In an attempt to further reduce the conduction of heat to the liquid helium, further testing and research is underway, with emphasis being placed on the effort to improve the construction of current-carrying leads. However, it has been generally believed that a heat conduction of 1 watt per 1,000 amps of applied current is unavoidable in the state of the art.

Another type of current-carrying lead for supplying an electric current to the superconducting devices is described in US-A-3,828,111. This particular current-carrying lead comprises a superconductor member, the ends of which are soldered respectively to the said conductors, a stabilising element integral with the central part of the superconductor member but isolated from its ends and a means for attaching the superconductor and the stabilising element to a rigid isolating support.

Current-carrying leads for use with superconducting magnets and like devices are also available in "detachable" form consisting of a socket. A plug and a prior art product of this type is illustrated in Fig. 2. A plug (21) made of copper is coupled to a terminal on the hot side (24) to a power source (note shown) via a normal conducting current-carrying lead (23) made of copper in rod, pipe or busbar form. A socket (22) is provided at a terminal on the cold side (26) to a superconducting magnet or like device (not shown). The plug (21) is inserted into the socket (22) for conducting current or is detached from the socket to cut off the current supply. The socket (22) is made of brass or copper and is furnished in its interior with one or more beryllium-copper, multi-face contactors (25), depending upon the current-carrying capability of the lead. The spring properties of the contactors are utilized to minimize the contact resistance between the plug (21) and socket (22).

The socket and plug in the above-described detachable current-carrying lead are made of copper conductors or brass (in the case of the socket) which are both good electrical conductors and good heat conductors as well. Accordingly, a Joule loss will occur as a result of a voltage drop that takes place in the material itself when current is applied and which also takes place due to the contact resistance between the socket and plug. The heat generated by this Joule loss is transmitted into the liquid helium, liquid nitrogen or other cryogenic media in which the superconducting magnet is submerged, and the heated cryogens will evaporate.

In order to ensure maximum current-carrying capability of the lead, the normal conducting metal must have a sufficient cross-sectional area. However. a greater area will result in increased heat condition from the hot area to the cryogenic medium. Research has been focused on methods to minimize this heat conduction to the cryogenic media. It has been found to date that a voltage drop of about 13 mV per 1,800 A of applied current is unavoidable between plug and socket. If a pair of leads having opposite polarities are used, the overall heat conduction is about $1{,}800\ \text{A} \times 0.013\ \text{V} \times 2 = 46.8$ W. Liquid helium used as a cryogen will evaporate in an amount of 1.4L/h per heat conduction of 1 W and as much as 65.52 L/h of liquid helium will volatilize under heat conduction of 46.8 W.

SUMMARY OF THE INVENTION

The present invention is intended to solve the aforementioned problems of the prior art current-carrying leads. An object, therefore, of the present invention is to provide a current-carrying lead to a superconducting device that is capable of suppressing the evaporation of liquid helium, liquid nitrogen and other cryogen in the superconducting device due to heat conduction.

This object of the present invention can be attained by a current-carrying lead comprising the features set out in claims 1 and 11, wherein the superconductor and support are bonded by adhe sion to form a unitary assembly. The support may be made of an insulator, a nonmagentic metal or a good electrical conductor.

The current-carrying lead of the present invention is formed of a composite that consists of a ceramic superconductor and a support made of an insulator, a nonmagnetic metal or a good electrical conductor, so it is substantially free from heat generation when current is applied at a temperature below the critical temperature (i.e.. the superconducting transition temperature). Under those conditions, heat conduction from a hot area to a cryogen, such as liquid helium or liquid nitrogen in a superconduction device, can be sufficiently reduced to suppress its evaporation.

PREFERRED EMBODIMENTS OF THE INVENTION

Figures 1 and 2 are longitudinal sections of two prior art current-carrying leads;
3. Figure 3 is a longitudinal section of a current-carrying lead according to a first embodiment of the present invention;
Figure 4 is a cross section of Figure 3 taken on line IV-IV; and
Figure 5 is a longitudinal section of a current-carrying lead according to a second embodiment of the present invention.

Representative embodiments of the present invention are described hereinafter with reference to the accompanying drawings.

Figure 3 is a longitudinal section of a pair of current-carrying leads 1, opposite in polarity, that are fabricated according to one embodiment of the present invention. Figure 4 is a cross section of Figure 3 taken on line IV-IV.

Each of the current-carrying leads 1 is in the form of a composite that consists of a superconductor 1a made of a ceramic oxide and a support 1b for the superconductor 1a that is made of an insulator such as FRP (fiber-reinforced plastics) or a nonmagnetic metal such as copper, aluminum or stainless steel. In a preferred embodiment, the support 1b is made of a nonmagnetic metal since it will serve not only as a support for the superconductor 1a but also as a stabilizer of the same.

A ceramic superconductor is disclosed, for example, in 1) Zeitschrift fur Physik B vol. 64. 1986 pages 189-193, J.G. Bednorz et al (La-Ba-Cu-O); 2) Japanese Journal of Applied Physics vol. 26. No. 1 January. 1987. P.L1-2, S. Uchida et al, (La-Ba-Cu-O): and 3) Physical Review Letters, vol. 58. No. 9 March, 1987, page 908-910, M.K.Wu et al (Y-Ba-Cu-O).

In order to fabricate the current-carrying lead 1, the superconductor 1a is first formed into an appropriate shape and subsequently bonded to the support 1b so as to make a unitary, composite structure. For making the two members into a unitary form by bonding, an organic material such as an epoxy resin is used as an adhesive agent and this method is preferred for commercial applications.

The current-carrying lead 1 may be used independently but in a preferred embodiment, two leads of opposite polarities are combined to make a pair (as in Figure 3). This combined structure offers the advantage of compactness, when compared to the case where individual leads are used separately.

The first embodiment of present invention in which a pair of current-carrying leads 1+, 1- are employed is described below in greater detail. A spacer 2 that extends longitudinally is provided between the two leads 1+, 1- and the assembly is supported by means of retainers 3 that are provided around the assembly and spaced along its axis.

If the support 1b is made of a metal, the spacer 2 is made of an insulator such as GFRP (glass-fiber reinforced plastics) or CFRP (carbon-fiber reinforced plastics). If the support 1b is made of an insulator, the spacer 2 may be made of an insulator or a metal, or may be omitted entirely. The retainers 3 may be insulating disks that are fitted onto the assembly of current-carrying leads and spacer, or may be a binding-insulating tape that is wrapped around the assembly.

If a current is passed through the pair of leads 1+, 1- and a magnetic field is applied to the circumference of the leads, the Lorentz force acting between one lead and the external field will push the Lorentz force acting between the other lead and the applied field in such a way that the two leads are pressed against each other. Therefore, the spacer 2 must be strong enough to withstand the compressive force acting between the two leads 1+, 1-. At the same time, the spacer must offer a satisfactory insulating distance between the two leads. On the other hand, the retainers 3 need not be as rugged as the spacer 2 and may be omitted or of a very small size. Because of this compactness, the embodiment shown in Figure 3 is advantageous for practical applications.

If a current is passed through the pair of leads when they are not magnetized, the leads will themselves generate a magnetic field. Since the current flows through the two leads in opposite directions, a Lorentz force will be exerted in such a direction that the two leads repel each other. Therefore, unlike the case where current is passed through the pair of leads with a magnetic field being applied to the circumference of the leads, the retainers 3 must be made more rugged than the spacer 2 when current is to be passed in the absence of any applied field. In Figure 3, a flange 4 may be seen with which the leads 1+, 1- are mounted on the top flange of a cryostat in such a way that the leads are electrically insulated from the cryostat. The assembly shown in Figure 3 also includes terminals 5+, 5- that may be connected to the hot side and terminals 6+, 6- that may be connected to the superconducting magnet (not shown).

The ceramic superconductor may be made by sintering materials known to be used for ceramic superconductors. Such materials may be available in elementary or compound forms that contain elements capable of producing superconductors. Illustrative elements having this property include group I elements, group II elements and group III elements of the periodic table as well as oxygen and fluorine.

More specifically, preferred Group I elements of the periodic table include Ia elements such as Li, Na, K, Rb and Cs, and Group Ib elements such as Cu, Ag and Au. Preferred Group II elements of the periodic table include

Group IIa elements such as Be, Mg, Ca, Sr, Ba and Ra, and Group IIb elements such as Zn and Cd. Preferred Group III elements of the periodic table include Group IIIa elements, such as Sc, Y, Lanthanoids (e.g., La, Ce, Gd and Lu), actinoids (e.g., Ac, Th, Pa and Cf), and Group IIIb elements such as Al, Ga, In and Tl. Preferred ceramic super-conductors are those which are composed of (i) an element selected from among Group Ib elements, (ii) an element selected from among Group IIa elements (notably in oxides), Group IIIa elements and lanthanoids, and (iii) an element selected from among oxygen and flourine. Preferred Group Ib elements are Cu and Ag.

When a current-carrying lead 1 was fabricated using an oxide ceramic superconductor 1a, the actual measurement of heat conduction from the hot area to a cryogen showed that the integral value of heat conduction for

$$4.2 - 300\ K\ (\int_{4.2K}^{300K} \lambda dT;$$

where λ is heat conductivity) was approximately 1,990 × 10^{-3} (W/cm). This value is approximate to those of glass and quartz and is about 1/800 of the value for electrolytic copper (1,620 W/cm) or 1/230 of that for phosphorus deoxidized copper (461 W/cm). It is therefore evident that the current-carrying lead of the present invention is very effective in suppressing heat conduction to cryogenic media.

If the support 1b, which is to be combined with the superconductor 1a, is made of an insulator such as a poly-tetrafluoro-ethylene resin. GFRP or CFRP, the heat conduction is further decreased to a much smaller value in the range of 700 × 10^{-3} to 1,000 × 10^{-3} (W/cm). Even if the support 1b is made of metal, current will not be passed through the metal, unlike the case of the prior art products, and the support 1b will function as a stabilizer or support for the superconductor 1a. Therefore, the cross-sectional area of the support 1b need not be made as large as the area found in the prior art versions in order to ensure the necessary current-carrying capability of the lead. The size of support 1b must be sufficient to simply enable the support 1b to function both as a stabilizer and support for the superconductor 1a. Therefore, this also contributes to a pronounced reduction in heat conduction to liquid helium and other cryogens.

Figure 5 is a longitudinal section of a current-carrying lead according to a second embodiment of the present invention. This is a detachable lead composed of a plug 11 and a socket 12. The plug 11 is formed as a composite in which a superconductor 11a, made of an oxide ceramic, is packed in a support 11b, made of a good electrical conductor such as copper or aluminum in pipe form. After packing the superconductor 11a into the tubular support 11b, the plug 11 is swaged, optionally followed by an expanding or contracting treatment, to obtain a desired length and shape.

The socket 12 into which the plug 11 is to be inserted is also readily fabricated. The powder of a ceramic superconductor 12a is placed on the outer surface of a support 12b made of a good electrical conductor such as copper or aluminum in pipe form and thereafter is bonded, to make a unitary assembly of the two members. The support 12b, made of a good electrical conductor in pipe form, is fitted in its interior with an appropriate number of multi-face contactors 13 made of beryllium-copper, depending upon the current-carrying capability of the lead. In Figure 5, two of such contactors are provided. The spring properties of the contactors are utilized to minimize the contact resistance between the plug and socket.

The support 12b is made of a good electrical conductor and is connected to a terminal 15 at the cold side and forms an integral part thereof. The terminal 15 also forms a unitary assembly with a superconductor 12a and is fabricated in the following manner. First, the powder of the superconductor 12a is placed on the surface of the terminal 15. Thereafter the powder is bonded, to make a unitary composite.

The ceramic superconductors 11a and 12a are the same as the ceramic superconductor 1a used in the first embodiment with respect to the material of which they are made and to the method of preparing them.

Both the support 11b of the plug 11, which is made of a good electrical conductor such as copper or aluminum in pipe form, and the support 12b of the socket 2, which is also made of a good electrical conductor such as copper or aluminum in pipe form, are preferably designed to have a minimum cross-sectional area in order to facilitate transfer of current from the superconductor 11a to 12a.

The supports 11b and 12b are formed of a high conductivity conducting metal. However, current is not to be passed through the metal, unlike the case of the prior art products, and these supports will function as a stabilizer and support for the superconductors 11a and 12a. Therefore, the cross-sectional area of each support need not be made as large as in the prior art versions in order to ensure the necessary current-carrying capability of the lead. As a result, the possible heat conduction to liquid helium or other cryogens can be significantly reduced.

The socket and plug in the conventional detachable current carrying lead are made of copper conductors or brass (in the case of the socket) which are good electrical conductors and good heat conductors as well. Accordingly, a Joule loss will occur as a result of a voltage drop that takes place in the material itself when current is applied and which also takes place due to the contact resistance between the socket and plug. The heat generated by this Joule loss is transmitted into liquid helium, liquid nitrogen or other cryogens in which a superconducting magnet is submerged, and the heated cryogen will evaporate. By contrast, the current-carrying lead according to the second embodiment of the present invention is in the form of a composite consisting of a ceramic superconductor and a support made of a good electrical conductor. This second embodiment structure is substantially free from the Joule loss that might occur as a result of voltage drop due to contact resistance between the socket and plug.

As described previously the current-carrying lead of the present invention is formed of a composite consisting of a ceramic superconductor and a support made of an insulator, a nonmagnetic metal or a good electrical conductor. If current is supplied to a superconducting magnet or devices through his lead when the lead is maintained at a temperature below the critical temperature for the superconductor, the occurrence of the Joule loss is reduced to a very low level. The support which is made of a nonmagnetic metal or good electrical conductor, functions merely as a support or stabilizer for the superconductor and is not required to have a current-carrying capability necessary for enabling it to work as a current-carrying member. Therefore, the cross-sectional area of the support can be sufficiently reduced to realize a significant decrease in the conduction of heat from the hot area to liquid helium and other cryogens. Since the evaporation of cryogens can be held to a minimum level, the cryogen tank does not need to be constructed in a large enough size to allow for the anticipated evaporation of cryogens during current application and the current-carrying lead of the present invention can be used with a compact cryogen tank.

The current-carrying lead of the present invention is particularly effective when it is used for a superconductive coil or similar device which is cooled by liquid helium and is also effective where cooling by liquid nitrogen is involved.

Claims

1. A current-carrying lead for a connection between a source of current supply and a superconducting device, said current-carrying lead comprising at least one superconductor member (1a, 11a) and a support (1b, 11b) for said superconductor member, wherein the support (1b, 11b) supports the superconductor member (1a, 11a) on the whole length from the current supply to the superconducting device;
characterized in that

said superconductor member comprises a ceramic superconductor being formed from a powder of a ceramic material into an appropriate shape adapted to the shape of the support (1b, 11b), and in that

said ceramic superconductor member (1a, 11a) and said support (1b, 11b) are a unitary composite structure through bonding by means of an adhesive agent made of an organic material.

2. A current-carrying lead according to claim 1 wherein said support (1b,11b) comprises an insulator.

3. A current-carrying lead according to claim 2 wherein said insulator comprises a material taken from the group consisting of glass fiber reinforced plastics, polytetrafluoro-ethylene resin and carbon-fiber reinforced plastics.

4. A current-carrying lead according to claim 1 wherein said support (1b,11b) is made of an electrical conductor.

5. A current-carrying lead according to claim 4 wherein said electrical conductor is a non-magnetic metal.

6. A current-carrying lead according to claim 5 wherein said non-magnetic metal is taken from the group consisting of copper, aluminum and stainless steel.

7. A current-carrying lead according to claim 1, wherein said superconducting device is cooled by liquid helium.

8. A current-carrying lead according to claim 1, comprising at least two superconductor members (1a) and a support (1b) for each superconductor members wherein said superconductor members are parallel in shape and said support is longitudinal in shape.

9. A current-carrying lead according to claim 8 which further includes a spacer (2) that is disposed between said supports in their longitudinal direction and a plurality of retainers (3) that are provided around the circumference of said ceramic superconductor members, said retainers being spaced along the longitudinal dimension of said support to retain said spacer supports and superconductor members in position.

10. A current-carrying lead according to claim 8 wherein at least one of said supports (1b) comprises an insulator.

11. A current-carrying lead according to claim 9 wherein at least one of said supports (1b) comprises a metal, said spacer (2) comprises an insulator, and said retainers (3) comprise a structure taken from the group consisting of a disk insulator and insulating tape.

12. A current-carrying lead for connection between a source of current and a superconducting device

comprising: a plug consisting of a first electrical conductor (11b) in pipe form and having an interior region,

a socket consisting of a second electrical conductor (12b) in pipe form and having an outer surface, and

at least one multi-face contactor (13) fitted in an interior region of said second electrical conductor in pipe form,

characterized in that

a ceramic superconductor (11a) is packed in said interior region of said first electrical conductor (11b) whereby said ceramic superconductor and said first electrical conductor are bonded by adhesion to form a unitary plug assembly;

and a ceramic superconductor (12a) is provided on said outer surface of said second electrical conductor (12b), said ceramic superconductor and said second electrical conductor are bonded by adhesion to form a unitary socket assembly.

13. A current-carrying lead according to claim 12 which further includes a terminal (15) to the cold side, said terminal being connected to said second electrical conductor and forming an integral part thereof, and a ceramic superconductor (12a) disposed on the surface of said terminal.

14. A current-carrying lead according to claim 12 wherein each of said first and second electrical conductors is taken from the group comprising copper and aluminium and said multi-face contactor is made of a beryllium-copper alloy.

15. A current-carrying lead according to claim 12, wherein said superconducting device is cooled by a liquid helium.

16. A current-carrying lead according to claim 1 wherein said ceramic superconductors comprise a material taken from (i) the group Ib elements, (ii) a material taken from the Group IIa elements, the Group IIIa elements and lanthanoids and (iii) a material taken from among oxygen and fluorine.

17. A lead according to claim 16 wherein said Group Ib elements comprise Cu and Ag.

18. A current-carrying lead according to claim 4 wherein said support is structured to have a minimized cross-section area.

Patentansprüche

1. Eine stromführende Leitung zur Verbindung zwischen einer Stromquelle und einer supraleitenden Einrichtung, wobei die stromführende Leitung wenigstens ein supraleitendes Bauteil (1a, 11a) und einen Träger (1b, 11b) für das supraleitende Bauteil umfaßt, wobei der Träger (1b, 11b) das supraleitende Bauteil (1a, 11a) auf der gesamten Länge von der Stromversorgung zu der supraleitenden Vorrichtung haltert;
dadurch gekennzeichnet, daß das supraleitende Bauteil einen keramischen Supraleiter umfaßt, der aus einem Pulver eines keramischen Materials in eine geeignete Gestalt geformt wurde, die an die Gestalt des Trägers (1b, 11b) angepaßt ist, und daß das keramische supraleitende Bauteil (1a, 11a) und der Träger (1b, 11b) einen einheitlichen zusammengesetzten Aufbau aufweisen durch Verbindung mittels eines Haftstoffs aus einem organischen Material.

2. Eine stromführende Leitung nach Anspruch 1, wobei der Träger (1b, 11b) einen Isolator umfaßt.

3. Eine stromführende Leitung nach Anspruch 2, wobei der Isolator ein Material aus der folgenden Gruppe enthält: glasfaserverstärkter Kunststoff, Polytetrafluoroethylenharz und kohlenstoffaserverstärktem Kunststoff.

4. Eine stromführende Leitung nach Anspruch 1, wobei der Träger (1b, 11b) aus einem elektrischen Leiter gebildet ist.

5. Eine stromführende Leitung nach Anspruch 4, wobei der elektrische Leiter ein nichtmagnetisches Metall ist.

6. Eine stromführende Leitung nach Anspruch 5, wobei das nicht-magnetische Metall aus der folgenden Gruppe genommen ist: Kupfer, Aluminium und rostfreier Stahl.

7. Eine stromführende Leitung nach Anspruch 1, wobei die supraleitende Einrichtung durch flüssiges Helium gekühlt ist.

8. Eine stromführende Leitung nach Anspruch 1 mit wenigstens zwei supraleitenden Bauteilen (1a) und einem Träger (1b) für jedes der supraleitenden Bauteile, wobei die supraleitenden Bauteile in der Form parallel sind und der Träger in der Form longitudinal ist.

9. Eine stromführende Leitung nach Anspruch 8, weiter mit einem Abstandshalter (2), der zwischen den Trägern in deren Längsrichtung angeordnet ist, und einer Vielzahl von Halteteilen (3), die um den Umfang der keramischen supraleitenden Bauteile angeordnet sind, wobei die Halteteile entlang der Längsdimension des Trägers voneinander beanstandet sind, um den Abstandshalter, die Träger und die supraleitenden Bauteile in ihrer Position festzuhalten.

10. Eine stromführende Leitung nach Anspruch 8, wobei wenigstens einer der Träger (1b) einen Isolator enthält.

11. Eine stromführende Leitung nach Anspruch 9, wobei wenigstens einer der Träger (1b) ein Metall enthält, der Abstandshalter (2) einen Isolator enthält und die Halteteile (3) eine Struktur umfassen, die aus der aus einem Scheibenisolator und einem Isolierband bestehenden Gruppe stammt.

12. Eine stromführende Leitung zur Verbindung einer Stromquelle und einer supraleitenden Vorrichtung mit:

einem Steckerteil mit einem ersten elektrischen Leiter (11b) in hohler Form mit einem inneren Bereich,

einer Steckhülse aus einem zweiten elektrischen Leiter (12b) in hohler Form und mit einer äußeren Oberfläche, und

wenigstens einem vielbahnigen Kontaktgeber (13), der in dem inneren Bereich des zweiten elektrischen Leiters in hohler Form eingepaßt ist,

dadurch gekennzeichnet, daß ein keramischer Supraleiter (11a) in den inneren Bereich des ersten elektrischen Leiters (11b) gepackt ist, wobei der keramische Supraleiter und der erste elektrische Leiter durch Anhaftung miteinander verbunden sind zur Bildung einer einheitlichen Steckeranordnung; und ein keramischer Supraleiter (12a) auf der äußeren Oberfläche des zweiten elektrischen Leiters (12b) vorgesehen ist, wobei der keramische Supraleiter und der zweite elektrische Leiter durch Anhaftung verbunden sind zur Bildung einer einheitlichen Steckeranordnung.

13. Eine stromführende Leitung nach Anspruch 12, weiter mit einem Anschluß (15) zur kalten Seite, welcher mit dem zweiten elektrischen Leiter verbunden ist und einen integrierten Teil von diesem bildet, und einem keramischen Supraleiter (12a), der auf der Oberfläche des Anschlusses angeordnet ist.

14. Eine stromführende Leitung nach Anspruch 12, wobei sowohl der erste als auch zweite elektrische Leiter aus der Gruppe von Kupfer und Aluminium entnommen ist und der vielbahnige Kontaktgeber aus einer Kupfer-Beryllium-Verbindung hergestellt ist.

15. Eine stromführende Leitung nach Anspruch 12, wobei die supraleitende Einrichtung durch flüssiges Helium gekühlt ist.

16. Eine stromführende Leitung nach Anspruch 1, wobei der keramische Supraleiter ein Material aus (i) der Gruppe der Ib-Elemente, (ii) ein Material aus der Gruppe der IIa-Elemente, der Gruppe der IIIa-Elemente und der Lanthaniden und (iii) ein aus Sauerstoff oder Fluor ausgewähltes Material enthält.

17. Eine stromführende Leitung nach Anspruch 16, wobei die Gruppe der Ib-Elemente Cu und Ag enthält.

18. Eine stromführende Leitung nach Anspruch 4, wobei der Träger mit einer minimalen Querschnittsfläche ausgebildet ist.

Revendications

1. Conduite transporteuse de courant destinée à relier une source d'alimentation en courant et un dispositif supraconducteur, ladite conduite transporteuse de courant comprenant au moins un élément supraconducteur (1a, 11a) et un support (1b, 11b) pour ledit élément supraconducteur où le support (1b, 11b) soutient l'élément supraconducteur (1a, 11a) sur toute la longueur de la source de courant au dispositif supraconducteur, caractérisée en ce que ledit élément supraconducteur comprend un supraconducteur céramique formé à partir d'une poudre d'une matière céramique en une forme appropriée adaptée à la forme du support (1b, 11b), et en ce que ledit élément supraconducteur céramique (1a, 11a) et ledit support (1b, 11b) sont réunis pour former un ensemble unitaire par adhésion au moyen d'un agent adhésif constitué par une matière organique.

2. Conduite transporteuse de courant selon la revendication 1, dans laquelle ledit support (1b, 11b) comprend un isolant.

3. Conduite transporteuse de courant selon la revendication 2, dans laquelle ledit isolant comprend une matière choisie dans le groupe formé par les matières plastiques renforcées par des fibres de verre, les résines de polytétrafluoroéthylène et les matières plastiques renforcées par des fibres de carbone.

4. Conduite transporteuse de courant selon la revendication 1, dans laquelle ledit support (1b, 11b) est constitué par un conducteur électrique.

5. Conduite transporteuse de courant selon la revendication 4, dans laquelle ledit conducteur électrique est un métal non magnétique.

6. Conduite transporteuse de courant selon la revendication 5, dans laquelle ledit métal non magnétique est choisi dans le groupe formé par le cuivre, l'aluminium et l'acier inoxydable.

7. Conduite transporteuse de courant selon la revendication 1, dans laquelle ledit dispositif supraconducteur est refroidi par de l'hélium liquide.

8. Conduite transporteuse de courant selon la revendication 1, comprenant au moins deux supraconducteurs (1a) et un support (1b) pour chaque supraconducteur, dans laquelle lesdits supraconducteurs sont de formes parallèles et ledit support est de forme longitudinale.

9. Conduite transporteuse de courant selon la revendication 8, qui comprend en outre une pièce d'écartement (2) qui est disposée entre lesdits supports dans leur direction longitudinale et une multiplicité de dispositifs de retenue (3) qui sont prévus autour de la circonférence desdits supraconducteurs céramiques, lesdits dispositifs de retenue étant écartés les uns des autres le long de la dimension longitudinale dudit support pour maintenir en position ladite pièce d'écartement, lesdits supports et lesdits supraconducteurs.

10. Conduite transporteuse de courant selon la revendication 8, dans laquelle au moins l'un desdits supports (1b) comprend un isolant.

11. Conduite transporteuse de courant selon la revendication 9, dans laquelle au moins l'un desdits supports (1b) comprend un métal, ladite pièce d'écartement (2) comprend un isolant et lesdits dispositifs de retenue (3) comprennent une structure choisie dans le groupe formé par un isolant en forme de disque et une bande isolante.

12. Conduite transporteuse de courant destinée à relier une source de courant et un dispositif supraconducteur, comprenant une fiche consistant en un premier conducteur électrique (11b) en forme de tube et comportant une région intérieure, une douille consistant en un second conducteur électrique (12b) en forme de tube, comportant une surface extérieure et au moins un contacteur multifaces (13) disposé dans ladite région intérieure dudit second conducteur électrique en forme de tube, caractérisée en ce qu'un supraconducteur céramique (11a) garnit ladite région intérieure dudit premier conducteur électrique (11b) de sorte que ledit supraconducteur céramique et ledit premier conducteur électrique sont réunis par adhésion pour former un ensemble formant fiche unitaire et un supraconducteur céramique (12a) est prévu sur ladite surface extérieure dudit second conducteur électrique (12b), ledit supraconducteur céramique et ledit second conducteur électrique étant réunis par adhésion pour former un ensemble formant douille unitaire.

13. Conduite transporteuse de courant selon la revendication 12, qui comprend en outre une borne (15) du côté froid, ladite borne étant reliée audit second conducteur électrique et faisant partie de celui-ci, et un supraconducteur céramique (12a) disposé sur la surface de ladite borne.

14. Conduite transporteuse de courant selon la revendication 12, dans laquelle chacun desdits premier et second conducteurs électriques est choisi dans le groupe formé par le cuivre et l'aluminium et ledit contacteur multifaces est constitué par un alliage béryllium-cuivre.

15. Conduite transporteuse de courant selon la revendication 12, dans laquelle ledit dispositif supraconducteur est refroidi par de l'hélium liquide.

16. Conduite transporteuse de courant selon la revendication 1, dans laquelle lesdits supraconducteurs céramiques comprennent (i) une matière choisie parmi les éléments du groupe Ib, (ii) une matière choisie parmi les éléments du groupe IIa, les éléments du groupe IIIa et les lanthanides et (iii) une matière choisie parmi l'oxygène et le fluor.

17. Conduite selon la revendication 16, dans laquelle lesdits éléments du groupe Ib comprennent Cu et Ag.

18. Conduite transporteuse de courant selon la revendication 4, dans laquelle ledit support est structuré de manière à présenter une aire de la section transversale minimisée.

FIG. 1
PRIOR ART

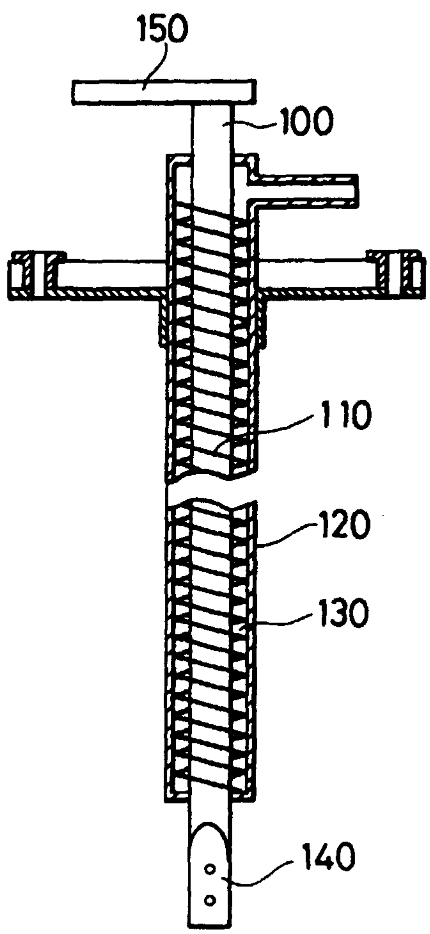

FIG. 2
PRIOR ART

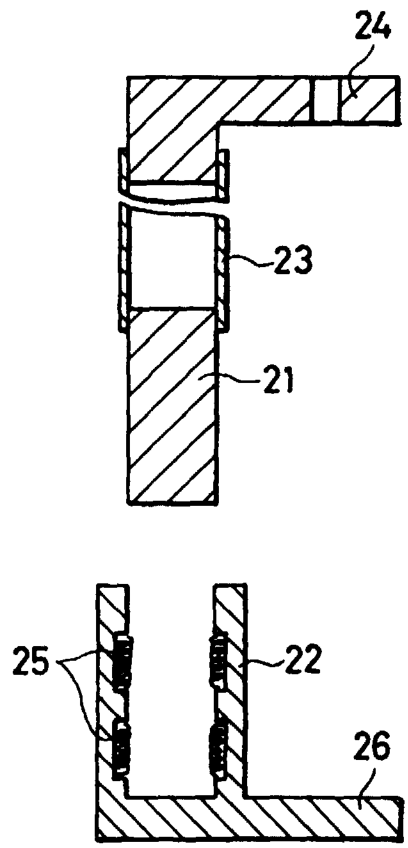

FIG. 3

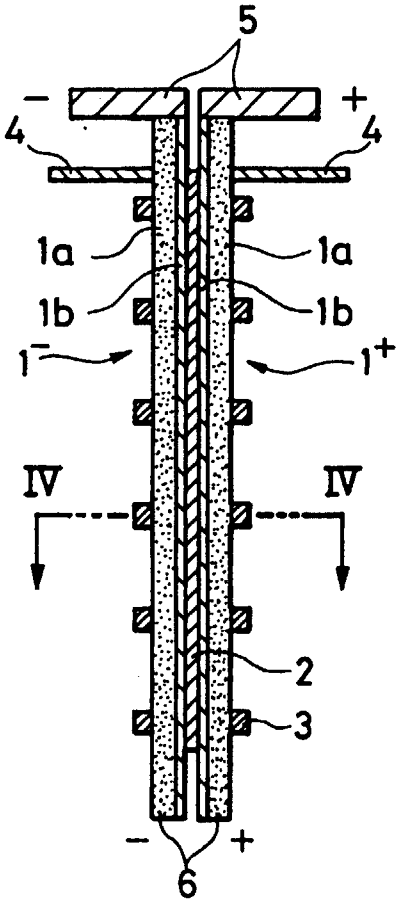

FIG. 4

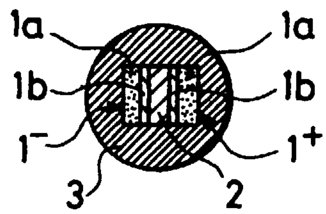

FIG. 5